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RICE CULTURE.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., July 29, 1910.

Sir: I have the honor to transmit herewith and to recommend for publication as a Farmers' Bulletin a manuscript entitled "Rice Culture," by Dr. S. A. Knapp, Special Agent in Charge of Farmers' Cooperative Demonstration Work, this being a revision of Farmers' Bulletin 110, issued in 1900.

Respectfully,

G. H. Powell,
Acting Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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RICE CULTURE.

INTRODUCTION.

Rice forms the principal food of one-half the population of the earth. It is more widely and generally used as a food material than any other cereal. Where dense populations are dependent for food upon an annual crop, and the climate permits its cultivation, rice has been selected as the staple food. The luxuriant growth of leguminous plants (beans, peas, etc.) at all seasons in tropical climates provides the nitrogenous food elements necessary to supplement rice. A combination of rice and legumes is a much cheaper complete food ration than wheat and meat and can be produced on a much smaller area.

VARIETIES OF RICE.

Rice is an annual plant belonging to the natural family of the grasses. There is an immense number of varieties of cultivated rice, differing in length of the season required for maturing, and in character, yield, and quality. Their divergence not only extends to size, shape, and color of the grain, but to the relative proportion of food constituents and the consequent flavor. South Carolina and Japan rices are rich in fats, and hence are ranked high in flavor and nutrition among rice-eating nations. A botanical catalogue enumerates 161 varieties found in Ceylon alone, while in Japan, China, and India, where its cultivation has gone on for centuries, and where great care is usually taken in the improvement of varieties by the selection of seed, no less than 1,400 varieties are said to exist.

Varieties grown in the United States.—The two principal varieties of lowland rice cultivated in the Atlantic States are the "gold seed," so called from the golden-yellow color of its husk when ripe, and the "white" rice, the original rice introduced into this country in 1694, which has a cream-colored husk and resembles the rice commonly grown in China.

The gold-seed rice, justly famous for the quality and large yield of the grain, stands, in the estimation of the market, among the first rices in the world. Along the Atlantic coast it has practically superseded the white rice which was generally cultivated in the earlier periods of the industry. The two varieties of gold-seed rice appear to differ little except that one has a slightly larger grain than the other. White rice is valued for its early maturity.

The principal varieties planted in Louisiana are the Honduras, named from the country which originally furnished the seed, and the more recently introduced Japan varieties. The Honduras is similar in general appearance and character to that of the Carolina rice, but it differs somewhat in quality of grain and the general growth of the plant. The Japan varieties have a short, thick kernel and a thin hull; the percentage of bran and polish is generally small; the straw is green when the grain is ripe, and the yield is generally large. The Kiushu is probably the best of the Japan varieties ever introduced into the United States.

Lowland and upland rice.—While rice is chiefly grown on lands that are low, level, and easily irrigated, there are varieties which can be grown on fertile uplands without irrigation. In the interior districts of India, China, and Japan upland rice is grown to a considerable extent, and experiments have demonstrated that it can be grown over large areas in the United States, but the crop is uncertain and in yield and quality considerably inferior to lowland rice produced by irrigation.

PRODUCTION AND IMPORTATION OF RICE.

Production.—The present annual production of rice in the United States is generally slightly less than the consumption. Even should our production equal our consumption, it is probable that a certain amount of rice would be imported by people who prefer the rice of their native countries. The Chinese, the Japanese, and the Italians import annually a certain amount for their own consumption, generally preferring not only the variety but the method of milling and preparing rice for market in their respective countries.

TABLE I.—*Annual average marketed production of cleaned rice in the United States from 1851 to 1880, by decades.*

[From statistics of Dan Talmage's Sons Co.]

Periods.	North and South Carolina.	Georgia.	Louisiana.	Total.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
1851-1860	84,359,840	18,610,320	....	102,969,660
1861-1870	[a] 16,185,857	[b] 11,107,880	5,734,555	....
1871-1880	29,024,040	16,247,340	29,630,274	74,901,654

[a] Average for seven years only, no production having been reported for 1861 to 1863.
[b] Average for five years only, no production having been reported for 1861 to 1865.

Production of rough rice in the United States in 1909, by States.

	Bushels.		Bushels.
North Carolina	13,000	Louisiana	12,675,000
South Carolina	476,000	Texas	9,894,000
Georgia	100,000	Arkansas	1,120,000
Florida	25,000		
Alabama	35,000	Total, nine States	24,368,000
Mississippi	30,000		

The total production of these nine States is equivalent to about 668,901,600 pounds of cleaned rice.

Imports.—The annual imports of cleaned rice into the United States for the fiscal years 1894 to 1899 averaged 120,648,311 pounds, and the imports of broken rice, flour, and meal 62,806,603 pounds, the whole having an average value of $3,200,011. The annual importation of rice of all varieties from 1905 to 1909, inclusive, amounted to 183,663,693 pounds, of which 69,912,819 pounds were for food purposes. From the above it will appear that the production of rice in this country can be considerably increased before the home market will be supplied.

The tariff on the various grades of rice imported into the United States ranges from one-fourth of 1 cent per pound on rice flour to 2 cents on cleaned rice.

RICE-GROWING SECTIONS.

Rice production in the United States is limited to the South Atlantic and Gulf States, where, in some sections, it is the principal cereal product. For nearly one hundred and ninety years after the introduction of rice into the United States, South Carolina and Georgia produced the principal portion, while North Carolina, Florida, Alabama, Mississippi, and Louisiana grew only a limited amount. Within the last ten years Louisiana, Texas, and Arkansas have increased the area devoted to rice to such an extent that they now furnish more than three-fourths of all the product of the country.

For fifteen years prior to 1861 the annual production of rice in North Carolina, South Carolina, and Georgia had averaged more than 105,000,000 pounds of cleaned rice. Of this, South Carolina produced more than three-fourths. But the industry in these States was wrecked by the war, and changed labor conditions, lack of necessary capital, and other causes have since prevented its full restoration. From 1866 to 1880, inclusive, the annual production of the three States averaged a little less than 41,000,000 pounds, of which South Carolina produced more than one-half.

Coincident with the breaking out of the civil war began the development of the rice industry in Louisiana. For a number of years the product was small, but during the seventies the industry began to assume large proportions, averaging nearly 30,000,000 pounds for the decade and exceeding 51,000,000 pounds in 1880. In 1885 the production of rice in Louisiana reached 100,000,000 pounds, and in 1892, 182,000,000 pounds; but these were years of exceptionally large crops.

The great development of the rice industry in Louisiana since 1884 has resulted from the opening up of a prairie region in the southwestern part of the State and the development of a system of irrigation and culture which made possible the use of harvesting machinery similar to that used in the wheat fields of the Northwest, thereby greatly lessening the cost of production. In 1896, however, a new difficulty began to be heavily felt. The varieties of rice which yielded best and were otherwise most satisfactory from a cultural standpoint under the new system proved inferior commercially because the percentage of grains broken in the process of milling was very large, and the proportion of "head rice," made up of the unbroken grains, was low. As the Japanese rices possess superior milling qualities, yielding a high percentage of head rice, it was desirable that they should be experimented with in this country. With this idea in view, the Department of Agriculture, in the spring of 1899, imported from Japan about 10 tons of Kiushu rice, which was distributed to experimenters in southwestern Louisiana, and elsewhere in the rice belt.

SOILS ADAPTED TO RICE.

The best soil for rice is a medium loam, containing about 50 per cent of clay. This allows the presence of sufficient humus for the highest fertility without decreasing too much the compact nature of the soil. The alluvial lands along the southern rivers, where they can be drained, are well adapted to rice cultivation. Occasionally such lands are too sandy. The rich drift soils of the Louisiana and Texas prairies have shown a marvelous adaptation to rice. These soils are underlain with clay so as to be retentive of water. The sand is exceedingly fine. There is about the right proportion of potash, phosphoric acid, and other essential mineral elements, with humus, to be lastingly productive.

Showing its wide range of adaptation, rice from the same sack has been planted in moist land and flooded, in cultivated upland fields, and on levees 18 inches above the water; and for a time it grew with almost equal vigor in each of these situations. The principal difference appeared in the maturing of the seed. Trials have been made with soils covered with a large amount of decayed vegetation. The results were generally disappointing. The roots of the rice, being shallow feeders, did not gain much hold upon the soil, and the decayed vegetation was not adapted to the rice plant. Rice has generally failed on peaty soils. Among the best rice lands of southeastern Louisiana are the so-called buckshot-clay lands, which are so stiff that they can hardly be plowed unless first flooded to soften them up.

The best rice lands are underlain by a semi-impervious subsoil. Otherwise the land can not be satisfactorily drained at time of harvest in order to permit the use of improved harvesting machinery. The alluvial lands along the Mississippi River in Louisiana are not underlain by hardpan, and they can not be drained sufficiently to permit the use of heavy harvesters and teams of horses.

Gravelly or sandy soils are not adapted to rice cultivation because they do not possess the mechanical conditions for the retention of water, and for other reasons above mentioned. Occasionally, on a light sandy soil, underlain by a stiff subsoil, one or two fairly good crops of rice may be grown, but this is the limit.

RICE LANDS.

Delta lands.—A large proportion of the rice grown in South Carolina and Georgia is produced on tidal deltas. A body of land along some river and sufficiently remote from the sea to be free from salt water is selected with reference to the possibility of flooding it from the river at high tide and of draining it at low tide. Lands of this class are also planted to rice in southern Louisiana.

Inland marshes.—Some excellent marshes are found in South Carolina and Georgia upon what may relatively be termed high land. These are in most cases easily drained and in many instances can be irrigated from some convenient stream. The objection that planters have found to such tracts is that the water supply is unreliable and not uniform in temperature. In case of drought the supply may be insufficient; in case of freshets the water is too cold. To obviate these objections reservoirs are sometimes constructed, but they are expensive, owing to loss by the evaporation from such a large exposed surface. However, where all the conditions are favorable, it costs less to improve these inland marshes than the delta lands, and the results are fairly remunerative.

Alluvial lands.—In eastern Louisiana rice is grown largely on low lands which were once used as sugar plantations; also on the well-drained alluvial lands farther up the Mississippi.

Prairie lands.—In southwestern Louisiana and southeastern Texas is a large area of comparatively level prairie land which has only within recent years been devoted to rice growing. These lands are a sufficient distance from the coast to be free from devastating storms and the serious attack of birds. No expensive clearing, ditching, or leveeing is needed to prepare the lands for rice. The drainage is good and the lands can be cultivated to winter crops, thus preventing the growth of red rice and injurious weeds and grasses. Such cultivation enables the planter to plow deeply in the fall and to fertilize. Plowing when done in the spring should be shallow. Here the methods of irrigation and culture are so different from those employed elsewhere as to deserve special treatment. (See page 27.)

Lands for upland rice.—The lands which are, or may be, devoted to growing rice without irrigation are so varied in character and location that no description can be given. In general it may be said that rice can be grown on any soil adapted to wheat or cotton provided climatic conditions are favorable. Rice is sometimes planted between the rows of cotton.

IRRIGATION.

Size of fields.—In rice culture the size of the fields depends on circumstances, chief among which are the slope of the land and the character of the soil as regards drainage. Fields range in size from 60 to 80 acres on the level prairies of southwestern Louisiana down to 1 or 2 acres along the banks of the Mississippi River. In oriental countries fields seldom contain more than a half acre. The entire surface of each field should be nearly at the same level so that the irrigation water will stand at about the same depth. Hence, where the slope of the surface is considerable, the fields must be made small. Fields must also be laid off in such a manner as to admit of effective drainage.

Canals and levees.—In coast-marsh and river-bottom culture a canal is excavated on the outer rim of the tract selected, completely inclosing it. The excavated dirt is thrown upon the outer bank to form a levee. The canal must be of sufficient capacity for irrigation and drainage. The levee must be sufficient not only to inclose the flooding water, but to protect the fields from the encroachment of the river at all seasons. When practicable the rice lands are flooded from the river, and find drainage by a canal or subsidiary stream that enters the river at a lower level. The embankment must be sufficient to protect the rice against either freshets or salt water. Freshets are injurious to growing rice, not only because of the volume of water, but by reason of its temperature. A great body of water descending rapidly from the mountains to the sea is several degrees colder than water under the ordinary flow. Any large amount of this cold water admitted to the field not only retards the growth, but is a positive injury to the crop. In periods of continued drought the salt water of the sea frequently ascends the river a considerable distance. Slightly brackish water is not injurious to rice, but salt water is destructive.

The tract of land selected and inclosed is then cut up by smaller canals into fields or subfields of suitable size, a small levee being thrown up on the borders of each. The entire tract is usually level, but if there should be any inequality care must be taken that the surface of each subfield be level. The main canal is 10 to 30 feet wide, about 4 feet deep, and connects with the river by flood gates. Through these canals boats of considerable tonnage have ready access to the entire circuit of the tract, while smaller boats can pass along the subcanals to the several fields. The subcanals are usually from 6 to 10 feet in width and should be nearly as deep as the main canal.

During the flooding period the ditches and canals become more or less filled by the mud which flows into them with the water. As soon after harvest as possible the ditch banks should be cleared of foul grasses, weeds, or brush, and the ditches cleaned. The levees should be examined to see if they are in repair.

The entirely different method employed in the prairie region of southwestern Louisiana and adjacent Texas is described on pages 27 to 29.

PREPARING THE GROUND.

Time to plow.—The time of plowing differs with different lands and circumstances, but in general it may be said that for wet culture plowing is done in the spring shortly before planting time. In the South Atlantic States, however, the land is often plowed or dug over with a hoe early in the winter. In some parts of southern Louisiana the land is so low and wet and the soil so stiff as to necessitate plowing in the water.

Deep plowing.—Some planters advocate shallow plowing for rice, because it appears to thrive best in compact earth. Even if this be granted, it does not prove the superiority of shallow over deep plowing. It has been demonstrated that the better the soil and the more thoroughly it is pulverized the better the crop. The roots of annual cultivated plants do not feed much below the plow line; it is therefore evident that deep cultivation places more food within the reach of the plant. If pulverizing the earth deeply be a disadvantage, by reason of the too great porosity of the soil at seeding time, it can be easily remedied by the subsequent use of a heavy roller. If the soil is well drained deep plowing will be found profitable. Deep plowing just before planting sometimes brings too much alkali to the surface. The remedy for this is to plow a little deeper than the previous plowings just after harvest. The alkali will then be washed out before the spring plowing. The plow should be followed in a short time by the disk harrow and then by the smoothing harrow. If the land is allowed to remain in furrows for any considerable time it will bake and can not be brought into that fine tilth so necessary to the best seed conditions. This is particularly true of rice land. If the best results are desired it will be advisable to follow the harrow with a heavy roller. The roller will crush the lumps, make the soil more compact, and conserve the moisture for germinating the grain, rendering it unnecessary to flood for "sprouting."

For dry culture the land is prepared very much as it is for a crop of oats.

DRAINAGE.

Perfect drainage is one of the most important considerations in rice farming, because upon it depends the proper condition of the soil for planting. It may appear unimportant that a water plant like rice should have aerated and finely pulverized soil for the seed bed, but such is the case. Thorough cultivation seems to be as beneficial to rice as to wheat. Complete and rapid drainage at harvest time allows the crop to be reaped under the best conditions and reduces the expense of the harvest.

Thorough drainage is even more essential for rice than for wheat, because irrigation brings the alkali to the surface to an extent that finally becomes detrimental to the rice plant. Alkali sometimes accumulates in the soil just below the depth of the usual furrow to such an extent that any plowing is dangerous to the crop. Experience has shown that there is but one effective way of disposing of these salts, and that is by thorough drainage and deep plowing. As the water drains away the excess of soluble salts is carried off. Now if the ditches are no deeper than the ordinary furrow it is evident that only the surface of the soil can be cleared. Either tiling must be employed or there must be plenty of open ditches, the main ones at least 3 feet deep.

Where the lands can not be thoroughly drained after the crop has matured there is liable to be an encroachment of water grasses which will grow so rapidly during the winter that they almost fully possess the field. If the soil can be drained sufficiently to enable the planter to put in a winter cover crop it will be found exceedingly profitable, in addition to preventing the establishment of these injurious grasses.

SOWING.

Selecting the seed.—Too great care can not be exercised in selecting rice for seed. It is indispensable that the seed should be free from red rice, grass, and weed seeds, uniform in quality and size of kernel, well filled, flinty, and free from sun cracks. Uniformity of kernel is more essential in rice than in other cereals, because of the polishing process.

Time to sow.—The best time to sow rice differs in different sections and varies somewhat with varying conditions in the same section. It may be sown between the middle of March and the middle of May, but in most cases it should be sown by April 20 for best results. Sowing should take place as soon as possible after spring plowing. Care must be taken to plant the several fields at different periods, so that harvest will not be too crowded.

Amount to sow.—The amount of rice sown per acre varies in different sections and with different methods of sowing, from 1 to 3 bushels per acre being used.

Germination.—Three different methods of treating the seed are followed. Some let on just enough water to saturate the ground immediately after sowing and harrowing and at once draw off any surplus water. This insures the germination of the seed. Others sow and trust to there being sufficient moisture in the land to germinate the seed. This is sometimes uncertain and rarely produces the best results. A few sprout the seed before planting by placing bags of rice in water. This is sure to be a failure if the soil is very dry when the seed is sown. In case of planting in dry soil without following with water saturation, rolling the land after seeding and harrowing has been found beneficial.

Drilling.—The rice should be planted with a drill. It will be more equally distributed and the quantity used to the acre will be exact. The seeds will be planted at a uniform depth and the earth packed over them by the drill roller. It also prevents the birds from taking the seeds. The roller should precede the drill. If it follows the drill the feet of the horses, mules, or oxen drawing the roller will press some of the planted rice 4 or 5 inches deeper into the earth than the general average. Furthermore, the lumps of earth will prevent the uniform operation of the drill. In rice farming too much emphasis can not be placed upon the importance of thoroughly pulverizing the soil to a considerable depth; leveling with a harrow as perfectly as possible; crushing all the lumps and packing the surface to conserve the moisture; and planting the seed at a uniform depth.

Broadcast sowing.—Broadcast sowing of rice is the method most in vogue in many localities, but it should be discontinued; the seed is never scattered with uniformity; some grains remain upon the surface and the remainder is buried by the harrow and the tramp of the teams to depths varying from 1 to 6 inches. Rice sown broadcast does not germinate with any uniformity. Some seeds are taken by the birds, some are too near the surface and lack moisture to germinate, while others are buried too deep. In some instances the variation in the germination of the rice in the same field has been as much as eight weeks. Then at the harvest when the main portion is ready for the reaper a good deal of the rice is still immature. The product commands a very low price in the market, because the merchantable grain must sell at the price of the low grade. It requires much more care to produce a strictly first-class quality of rice than is found necessary in the production of any other cereal, and nearly every fall prime offerings are the exception.

The South Carolina method.—Seeding in South Carolina commences in April and continues nearly to the middle of May. Just prior to seeding the land is thoroughly harrowed, all clods pulverized, and the surface smoothed. Trenches 12 inches apart and 2 to 3 inches deep are made with 4-inch trenching hoes at right angles to the drains, and the seed is dropped in these. This is usually covered, but occasionally a planter, to save labor, stirs the seed in clayed water, enough clay adhering to the kernels to prevent their floating away when the water is admitted. Great attention is paid to the selection of good seed.

FLOODING.

Flooding is the most important distinctive feature of rice culture as compared with the culture of cereals generally. When it is considered that rice can be grown successfully without any irrigation whatever, or with continuous irrigation from the time of sowing till nearly ripe, the wide scope there is for variation in practice will be realized.

General directions.—Except where water is necessary for germinating the seed, flooding is not practiced until the rice is 6 to 8 inches high. If showers are abundant enough to keep the soil moist it is better to delay flooding till the rice is 8 inches high, as there is considerable danger of scalding the rice when very young. At 8 inches high a sufficient depth of water can be allowed on the field to prevent scalding. The depth of water that should be maintained from the first flooding until it is withdrawn for the harvest depends upon other conditions. If the growing crop thoroughly shades the land, just enough water to keep the soil saturated will answer. To be safe, however, for all portions of the field, it should stand 3 to 6 inches deep, and, to avoid stagnation, it should be renewed by a continuous inflow and outflow. In case the stand of rice is thin the water should be deeper. A flow of water through the field aids in keeping the body of the water cool and in preventing the growth of injurious plants that thrive in the stagnant water. The water should stand at uniform depth all over the field. Unequal depths of water will cause the crop to ripen at different times.

Where the lands are sufficiently level and have excellent drainage the tillering of the rice can be greatly facilitated by keeping the soil saturated with water but not allowing enough to cover the surface. In this way the crop is frequently nearly double what it would be if allowed to grow dry until tall enough to flood or if flooded before fully tillered.

The practice in South Carolina.—Under the usual method the water is let on as soon as the seed is covered, and remains on four to six days, till the grain is well sprouted. It is then withdrawn. As soon as the blade is up a few inches the water is sometimes put on for a few days and again withdrawn. The first water is locally called the "sprout water." After the rice has two leaves the so-called "stretch water," or "long-point flow," is put on. At first it is allowed to be deep enough to cover the rice completely—generally from 10 to 12 inches—then it is gradually drawn down to about 6 inches, where it is held twenty to thirty days. It is then withdrawn and the field allowed to dry. When the field is sufficiently dry the rice is hoed thoroughly, all grass and "volunteer" rice being carefully removed. After hoeing, it remains without irrigation until jointing commences, when it is slightly hoed, care being used to prevent injury to the plants, and the water is then turned on again. During the time water is held on the rice it is changed at least every week to avoid its becoming stagnant. When this occurs rice is liable to be troubled with the water weevil. This "lay-by flow," or final irrigation, continues until about eight days before the harvest, when the water is drawn off for the field to dry.

UNIFORM RIPENING.

The planter should particularly note the importance of not making the fields too large. It impedes complete drainage. It is inconvenient to have large ditches intersecting the fields. The simultaneous maturity of all portions of the field is desirable if it is to be cut with a twine binder. This can be secured by uniform and good drainage, by plowing, harrowing, planting, and rolling the same day, and by planting the seed equally deep and distributing it evenly. No field should be so large that the work of planting can not be completed within three or four days. The flooding water must stand in all portions of the field at equal depth and temperature.

Rice should be cut when the straw has barely commenced to yellow. If cutting is delayed till the straw shows yellow to the top the grain is reduced in quality and quantity and the straw is less valuable. There is also a considerable increase in the loss by shelling in handling in the field.

FERTILIZING.

Rice is not a great impoverisher of the soil, especially if the straw and chaff are regularly returned to it.

It has been claimed that the flooding of the rice fields restores to the soil as much nutritive material as the rice crop removes. Where lands are flooded from rivers like the Mississippi or the Nile, which carry a large amount of silt, this may be true. It is not the case where flooding is done with pure water. The continued fertility of the rice field can only be maintained by restoring to the soil annually a portion of what the crop removes. Whether this can be more economically done by the use of commercial fertilizers and plowing under of the rice straw, or by fallowing occasionally and using some renovating crop as a green manure is an economic question to be determined by each planter according to the conditions presented. Repeated trials of commercial fertilizers have almost invariably shown gains in the quality and quantity of the crop more than sufficient to cover the cost. Summer fallowing, where it can be practiced, is, in addition to its renovating effect, a substantial aid in destroying noxious grasses and red rice.

There is very little exact information on the subject of fertilizers for rice. In Japan and other oriental countries a large proportion of the rice land is thoroughly fertilized in the fall with straw, leaves, rice hulls, fish, and night soil. The fields are planted to wheat or vetches for the winter crop, followed the next spring by rice without additional manures.

WEEDY GRASSES.

In all delta rice lands the rapid increase of injurious grasses becomes a serious difficulty. This is intensified along the Mississippi by the large amount and wonderful variety of grass seed in the river water. The conditions favorable to the growth of rice also favor the growth of many grasses, and these wild plants are naturally more hardy than their cultivated competitor. In the early years of rice culture in eastern Louisiana plantations were leased, in many instances, and planted a few years while they produced a maximum crop; then they were abandoned for other lands which had not hitherto been planted in rice. This change of lands was due to the rapid increase of harmful grasses, many of which were conveyed to the fields by the irrigating water and appeared to find such congenial conditions for growth that in about three years they were practically in full possession. In a short time it became evident that the practical supply of plantations for such purposes was limited, and that the planters must make a more vigorous and successful warfare on these invaders of their fields. The following are the methods most generally employed against these harmful grasses, with their advantages and defects.

Hand weeding.—By hand weeding, grasses can be effectually destroyed, and at the same time the rice crop greatly benefited by the loosening up of the soil consequent on pulling up the grass. But hand weeding is too tedious and expensive to be generally employed by the large planters.

Mowing and burning the grasses.—After the rice is harvested, some time should be allowed for the growth of grass and suckers from the rice stubble, so that when cut there will be enough straw to burn well. Then the stubble should be cut with a mowing machine and the ground burned over. The fire should destroy not only the seeds but the roots, so that there will be no more suckering. A serious objection to this plan is that it leaves the land perfectly bare to be parched by the hot sun and baked so hard as to be difficult to plow. It would appear that this difficulty might be removed by sowing a crop of winter oats or other forage crop after burning over the ground.

A better plan, provided the field is to remain fallow, is to wait until the grass is killed by frost, then burn over the ground. In this way some seed will be destroyed. Left exposed, some other will be destroyed by ice, and the remainder, feeling the warmth much earlier, will germinate in time to be destroyed by plowing. But this will make the planting comparatively late, and the planter will lose the benefit of the early market for the crop.

Winter flooding.—Attempts have been made to destroy the grass by flooding the lands during the winter, but the result has been unsatisfactory. It appears that the grass seeds will not rot without germinating, and they will not germinate in cold water.

Early planting and mowing.—Planters frequently adopt the plan of sowing early and, when the rice and grass have both got a good start, mowing them off and trusting to the rapid growth of the rice to smother out its slower growing rivals. This it generally does, but its race for life absorbs all its energies and gives it no chance to sucker, thus materially reducing the yield.

Fall plowing.—Shallow plowing and harrowing or thorough disking immediately after harvest, provided the weather is warm enough for the rapid germination of seeds (not later than September), is quite effective against injurious grasses and red rice. Deep plowing simply buries the seed and preserves it for future growth. The shallower the plowing the better, and if there is not sufficient moisture slight irrigation should be resorted to after the plowing.

It will be seen that there are objections to every method described, and some of them are complete failures. Next to hand weeding, the methods which involve the burning over of the ground are doubtless the most effective in eradicating the grass, but summer fallowing with shallow plowing and the employment of some densely growing crop like cowpeas or velvet beans will, all things considered, be the most advantageous for the soil and most efficacious for the eradication of the injurious grasses.

RED RICE.

Red rice, a wild variety having red grains, causes the rice growers much annoyance and loss. The presence of a few red grains in milled rice lowers its grade and reduces its price. If red rice once gets a foothold in a field it increases rapidly from year to year until finally the product becomes unsalable.

The red rice and the common white rice are two separate and distinct strains. The seed of one will not produce the other. Being stronger, hardier, and more persistent than the cultivated white rice, the former becomes a dangerous weed in the rice field. Its first start comes from the sowing of seed containing red grains. The fields are reseeded from year to year mainly in this way: After the crop is harvested the stalks which have been cut off frequently send out suckers from the lower joints which mature seed. As these seeds possess remarkable resistance to premature germination, spring finds the ground well sown with red rice.

Remedies.—Two things must be accomplished to keep the field clear of red rice: First, seed planted must be free from red rice, and the utmost caution must be exercised to secure this; second, red seed, if accidentally planted, must be prevented from maturing in the field.

To this end it is exceedingly important to prevent a second crop of red seed from maturing after the general harvest, which is almost certain to occur if the field is left fallow till the following winter. The land should be well drained at the time of the harvest, and within a few weeks thereafter the stubble should be plowed under. In October the land should be thoroughly cultivated with a disk harrow and sown to oats for winter pasture. If the harvest be early, the stubble may be plowed under immediately and the field planted to vetches or crimson clover for pasture. In pasturage care should be exercised not to allow any stock on these fields in wet weather. It is quite customary to burn the stubble. This may destroy a few seeds and prevent sprouts from maturing seed, but it destroys fertilizers and leaves the land bare. Fall plowing and planting to forage crops is far more advantageous. Plowing in the early spring and thorough cultivation just before planting are helpful in reducing the red rice, but not sufficient for complete eradication.

While some of the methods mentioned for eradicating weeds and red rice are helpful, none of them has proved completely successful except summer fallowing with cowpeas or planting in corn. This plan increases the fertility of the soil, so that more rice is produced in a series of years than by uninterrupted cropping with rice.

On new land, seed absolutely free from red rice should be used; then, with care, the land may be kept free from it. In case land is already filled with it, if sufficiently well drained, cultivate to corn or cotton a few years; if not sufficiently well drained, summer fallow; if this can not be done, pasture to sheep or hogs. Every rice planter should use great care, in selecting a new piece of ground upon which to raise seed, to choose a plot without possible taint of red. The seed should be examined so closely as to prevent the sowing of any red seed.

HARVESTING.

Reaping machines are generally used in the prairie districts of Louisiana and Texas, but in the other rice-producing sections such machines can be used only to a limited extent, if at all. The principal obstacle to the use of large and heavy machinery is that the ground is not sufficiently dry and firm at harvest time. In some cases the smallness of the fields is also an obstacle.

Where the use of reaping machines is impracticable, the sickle is the implement commonly used in harvesting rice. The rice is cut at 6 to 12 inches from the ground, and the cut grain is laid upon the stubble to keep it off the wet soil and to allow the air to circulate about it. After a day's curing, the grain is removed from the field, care being taken not to bind it while it is wet with dew or rain. The smaller the bundles the better will be the cure.

Care in shocking is also important. Thirty per cent of the crop may be lost by improper shocking. The following directions will aid: First, shock on dry ground; second, brace the bundles carefully against each other, so as to resist wind or storm; third, let the shock be longest east and west and cap carefully with bundles, allowing the heads of the capping bundles to fall on the north side of the shock to avoid the sun. Exposure of the heads to sun and storm is a large factor in producing sun-cracked and chalky kernels, which reduce the milling value. Slow curing in the shade produces the toughness of kernel necessary to withstand the milling processes. In the shock every head should be shaded and sheltered from storm as much as possible. The rice should be left in the shock till the straw is cured and the kernel hard.

When the weather is dry, ten or twelve days after cutting is sufficient for completely curing the grain. If the weather is damp or rainy, the farmer must use his best judgment in determining the number of days necessary for the curing.

Whether stacking rice from the shock is a benefit depends upon the condition of the grain and straw at the time of stacking and how the stacking is done. If too much heat is generated, stacking is an injury. It is, moreover, of less importance with rice than with wheat.

Judging from the practice in other countries, rice well cured in the shock and aired after thrashing ought to keep in the bin without heating.

THRASHING.

The primitive methods of "flailing," "treading out," etc., have largely given place to the use of the steam thrasher, though its use frequently involves considerable loss through breakage and waste of grain. Great care should be exercised to avoid this and preserve every part which has been won from the soil with such labor. At the commencement of thrashing an examination should be made to see that there is no avoidable breakage of the grain. If the rice is damp when delivered from the machine, it should be spread upon a floor and dried before sacking, so as to be in the best condition for the market, for color of grain affects the value. One great mistake made by many farmers is to sack the rice when it is really wet, without airing and drying. They claim that it will dry out in the sack. It will, but drying under such conditions promotes chalkiness and in extreme cases makes the rice almost worthless.

THE QUESTION OF LABOR.

The expense of labor in the rice fields is one of importance to the planter. While American labor is the highest paid in the world, it is also the most effective. The great variations in wages and in the area which can be cultivated by the laborer in different countries are shown in the following table:

TABLE II.—*Number of acres one man can farm in rice, with wages, in different countries.*

Country.	Acres.	Farm wages per day, with board.	Country.	Acres.	Farm wages per day, with board.
Japan	½	$0.10 to $0.20	Spain	5	$0.30 to $0.50
China	½ to 2½	.08 to .15	United States:		
Philippines	2½	.25 to .35	Carolinas	8	.60 to .80
India	3	.05 to .10	Arkansas		1.00 to 1.25
Siam	3	.05 to .10	Southwestern Louisiana and		
Egypt	4	.20 to .30	Texas	80	1.50 to 2.00
Italy	5	.30 to .50			

These figures show that the high wages paid in the United States need not stand in the way of the extension of the industry.

YIELD OF RICE.

The yield of rice varies with conditions of soil and climate and methods of culture. The commercial standard weight of "rough rice" is 45 pounds to the bushel. The product is usually put up in sacks or barrels of 162 pounds each. A barrel is a definite quantity—162 pounds. A sack is an indefinite quantity, but usually contains from 150 to 200 pounds.

In South Carolina and Georgia the average yield is given as 8 to 12 barrels. Good lands properly managed will give a considerably larger yield.

A prominent planter, speaking of rice crops on the lowlands along the Mississippi, says:

Under my own observation there has been produced on this land as high as 30 barrels (4,860 pounds) of rough rice per acre. This was upon good land that had been in peas and had been fall plowed with 6-mule teams. The average product per acre on the lower coast (Mississippi River) will not exceed 8 barrels, and 12 barrels is considered a good crop.

The yield in southwestern Louisiana is said by good authority to range from 8 to 18 barrels per acre.

In a report made by planters to the Savannah Rice Association, January 28, 1882, the average yield to the acre is placed at 30 bushels, and the annual cost of cultivation, including interest on the land, at $35 per acre. In a report made by prominent rice planters to the House Committee on Ways and Means in January, 1897, the average yield to the acre is placed at 32 bushels, and the cost of production is fixed at $24. If we take the latter estimate, the cost to the planter in the Atlantic States of raising 100 pounds of rough rice is $1.66, or $2.69 per barrel of 162 pounds. Of course this is only an average, the cost being much less in some instances and possibly greater in others.

RICE MILLING.

Object of milling.—The rice as it comes from the thrasher is known as "paddy" or "rough rice." It consists of the grain proper with its close-fitting cuticle roughly inclosed by the somewhat stiff, hard husk. The object of milling is to produce cleaned rice by removing the husk and cuticle and polishing the surface of the grain. The hulls or chaff constitute from 12 to 25 per cent of the weight of the paddy, depending on the variety and condition.

Primitive methods.—The primitive method of milling rice was to place a small quantity of paddy in a hollow stone or block of wood and pound it with a pestle. The blow with the pestle cracked the hull, and the friction created by the sliding motion of the rice under the blow released the hull and the cuticle. The bran and hulls were then removed by winnowing. The first advance upon this primitive mechanical process was to make the receptacle for the rice out of a short section of a hollow log, using a heavy wooden pounder bound to a horizontal beam 6 to 8 feet long, resting on a fulcrum 4 to 5 feet from the pounder. To raise the pounder the operator stepped on the short end of the beam; then he suddenly stepped off and the pounder dropped into the rice tub and delivered a blow. The end of the pounder was concave with edges rounded. This simple machine and the fanning mill are in common use in oriental countries to this day. Such a mill cleans about 11 bushels (a trifle over 3 barrels) of paddy rice per day, at a cost of 6 cents (gold) per barrel.

In time water power was used to turn an overshot wheel, which was geared to a long horizontal shaft, with arms at distances apart equal to that of the rice pounders. The rice pounder was a vertical beam about 10 feet long and 6 inches square, with a pin projecting at a point to be caught by the rounded end of the arm of the revolving shaft, which raised the pounder a short distance, then slipped past the pin, allowing the pounder to drop into the tub of rice. This process was repeated until the hull and bran were removed. The rice tubs stood in a row as closely as practicable for use. Generally, to economize space, there were two shafts revolving in opposite directions, allowing two rows of rice tubs. In every mountain village in Japan such mills may be found preparing the rice for local consumption. They usually have about eight pounders and mill 96 bushels daily, or $26\frac{2}{3}$ barrels, of paddy rice at a cost of about 2 cents per barrel, which is more than paid for by the offal. In cities steam power is used and the number of pounders greatly increased, but the process is practically unchanged.

Modern methods.—The improved processes of milling rice are quite complicated. The paddy is first screened to remove trash and foreign particles. The hulls, or chaff, are removed by rapidly revolving "milling stones" set about two-thirds of the length of a rice grain apart. The product goes over horizontal screens and blowers, which separate the light chaff and the whole and broken kernels. The grain is now of a mixed yellow and white color. To remove the outer skin the grain is put in huge mortars holding from 4 to 6 bushels each and pounded with pestles weighing 350 to 400 pounds. Strange to say, the heavy weight of the pestles breaks very little grain.

When sufficiently decorticated the contents of the mortars, consisting now of flour, fine chaff, and clean rice of a dull, filmy, creamy color, are removed to the flour screens, where the flour is sifted out; and thence to the fine-chaff fan, where the fine chaff is blown out. On account of the heat generated by the heavy frictional process through which it has just passed, the rice next goes to the cooling bins. It remains here for eight or nine hours, and then passes to the brush screens, whence the smallest rice and what little flour is left pass down on one side and the larger rice down the other.

Polishing.—The grain is now clean and ready for the last process—polishing. This is necessary to give the rice its pearly luster, and it makes all the difference imaginable in its appearance. The polishing is effected by friction against the rice of pieces of moose hide or sheepskin, tanned and worked to a wonderful degree of softness, loosely tacked around a revolving double cylinder of wood and wire gauze. From the polishers the rice goes to the separating screens, composed of different sizes of gauze, where it is divided into its appropriate grades. It is then barreled and is ready for market.

Hulling machines.—In mills more recently erected the foregoing process has been modified by substituting the "huller" for the mortar and pounder. The huller is a short, cast-iron, horizontal tube with interior ribs and a funnel at one end to admit the rice. Within this tube revolves a shaft with ribs. These ribs are so adjusted that the revolution of the shaft creates the friction necessary to remove the cuticle. The rice passes out of the huller at the end opposite the funnel. It resembles externally a large sausage machine. Six hullers are required for each set of burs. The automatic sacker and weigher is used, sacks instead of barrels being preferred for shipping the cleaned rice.

With the above modification of the milling processes considerable reduction has been made in the cost of the mill. Mills of a daily capacity of 60,000 pounds of cleaned rice can now be constructed at a total cost of $10,000 to $15,000.

A portable mill.—A portable rice mill has also been devised for plantation use, costing $250 to $300, aside from the power to run it, and capable of cleaning 8,100 pounds of paddy rice per day. Such small machines do not give the finish required by the general market, but turn out excellent rice for local use.

EFFECTS OF FASHION IN RICE.

Effect of polishing.—Fashion demands rice having a fine gloss. To supply this the rice is put through the polishing process, which removes some of the most nutritious portions of the rice grains. Estimated according to the food values, rice polish (or flour) is 1¾ times as valuable for food as polished rice. The oriental custom, much used by farmers in the South, of removing the hulls and bran with a pounder and using the grain without polishing is economical and furnishes a rice of much higher food value than the rice of commerce. In the process of polishing nearly all the fats are removed. In 100 pounds of rice polish there are 7.2 pounds of fats. In 100 pounds of polished rice there is only 0.4 pound of fat. Upon the theory that the flavor is in the fats, it is easy to understand the lack of flavor in commercial rice and why travelers universally speak of the excellent quality of the rice they eat in oriental countries.

Grades and prices.—Aside from the loss in flavor and nutritive value by polishing, fashion again increases the cost of commercial rice by demanding whole grains and places a value of about 2 cents per pound more on head rice (whole grains) than on the same quality slightly broken. The weekly New Orleans market report for July 16, 1910, makes the following quotations on cleaned rice per pound:

	Price of Honduras rice.	Price of Japan rice.
Head	\$0.04¼ to \$0.06½	\$0.02¼ to \$0.03½
Straights (slightly broken)	.03 to .04	.01⅝ to .02¼
Screenings (partly broken)	.02 to .02½	.02 to .02¼
No. 2 (finely broken, or brewers' rice)	.02	.02

Such a large proportion of Japan rice comes from the mill as whole grains or head rice that even at the lower price it makes the grain profitable.

These grades are determined not by the difference in quality, but by appearance, and may be manufactured from the same quality of paddy rice. There may be a slight difference in food value between No. 2 (fine rice sold to brewers) and fancy, but if any it is trifling. If rice is to enter largely into the list of economic foods for the use of the masses, grades must be established based on the food values and not on the polish of the surface. It would be just as sensible to place a price on shoes according to the polish they will take.

Losses by breakage.—We are now prepared to understand the loss by breakage of the kernel in milling. If the grain remains whole and is sufficiently hard to receive a high polish it sells for 6 cents per pound. If it breaks it drops in price 2 or 3 cents per pound, and if it crumbles so that the particles will pass through a No. 12 sieve the price may be 1⅝ cents per pound. The question is, What is the average breakage per 100 pounds and how can it be remedied? Investigations made among the rice millers in 1897 led to the conclusion (based upon their written statements) that the perfect grains in Honduras rice were only about 40 per cent of the total product. Letters addressed to the various rice mills have failed in most cases to elicit the information. The president of the New Orleans Board of Trade states in a letter: "The second part of your letter we are unable to answer as a proposition, for the reason that different mills achieve different results, and there is no way by which the trade can arrive at an average of the yield made by the different mills, this information as a rule being carefully guarded." In the few reports received the grading of the milled product was so different that no conclusions could be drawn as to the relative amount obtained by the mills. In the mills reporting, the best lots of rice milled in 1899 showed a breakage of 21½ to 40 per cent and the poorest lots showed from 65 to 100 per cent. The best lots of rice gave from 100 to 112.9 pounds of milled rice from 162 pounds of paddy; the poorest gave only from 63.6 to 85 pounds from the same quantity of paddy.

The total loss by breakage in the United States approximates $2,000,000 annually. A large proportion of this can be saved by selecting better seed, by more careful attention to the field management in the production of the crop, and by more care in curing and thrashing; and to this should be added more care in milling or milling by processes that produce the least breakage.

RICE AS A FOOD.

As a food material rice is nutritious and easily digested. In comparison with wheat it is poor in nitrogeneous material and fat, and correspondingly rich in nonnitrogenous substances (carbohydrates).

Results of analyses.—Analyses show that 100 pounds of cleaned rice contain 87.7 pounds of total nutrients, consisting of 8 pounds protein, 0.3 pound fat, 79 pounds carbohydrates, and ash 0.4 pound. In comparison with this, 100 pounds of wheat flour contain 87.2 pounds of total nutrients, consisting of 10.8 pounds protein, 1.1 pounds fat, 74.8 pounds carbohydrates, and 0.4 pound ash.[a] The ease with which the deficiency of albuminoids and fats can be supplied from legumes and the almost absolute certainty of producing a crop every year are the principal reasons why rice is the staple food in many densely populated countries.

It is claimed that boiled rice is digestible in one hour, and hence is an admirable food when ease of digestion is a matter of importance. Rice should be at least three months old before it is used for food.

Food uses.—In rice-producing countries rice is used in the daily foods as a substitute for Irish potatoes and wheat bread. It is eaten alone with a little dried fish or other material to balance the ration. In China, Japan, and Java soy sauce, soy-bean cheese, or other similar product is eaten with rice in considerable amounts and furnishes a large part of the protein necessary in the daily diet. In the rice districts of the United States rice is used in place of the Irish potato. Boiled rice, flaked rice, rice puddings, croquettes, cakes, and many other well-known dishes made from rice form a part of the diet of many, if not of the majority, of the well-to-do families in the rice-producing sections of the United States. Such dishes are palatable and wholesome and help to give variety in diet. Rice polish or flour, which is now sold at the mills at three-fourths of a cent to 1 cent a

[a] Bulletin 28, rev., Office of Experiment Stations, U. S. Dept. of Agriculture.

pound for cattle food, or exported to Germany, will, when appreciated, be in demand for human food. It contains 10.95 per cent of protein, in comparison with 7.4 per cent for the clean rice.

BY-PRODUCTS OF RICE CULTURE.

Results of analyses.—Rice bran contains 12.1 per cent protein, 8.8 per cent fat, and 59.4 per cent fiber and carbohydrates; rice hulls, 3.6 per cent protein, 0.7 per cent fat, 35.7 per cent fiber, and 38.6 per cent other carbohydrates; and rice polish, 11.7 per cent protein, 7.3 per cent fat, and 64.3 per cent fiber and carbohydrates.[a] According to an estimate made by Doctor Stubbs, director of the Louisiana experiment station,[b] rice polish is worth $21.55 per ton; rice bran, $20.80; rice straw, $9.13; and rice hulls, $8.34. These values are based on the assumption that the nutritive elements in rice are digestible in the same degree as those contained in the by-products of wheat and other cereals.

Straw.—Rice straw is worth preserving. As a fodder for stock its value is about equal to good southern prairie hay. Rice straw contains 4.72 per cent crude protein, 32.21 per cent carbohydrates, and 1.87 per cent fats. The sweetness and excellent flavor of well-preserved rice straw adds very materially to its practical feeding value, because stock will consume large quantities of it. Digestion experiments have not been made with the straw or any of the by-products of rice milling.

Rice hulls.—The hulls removed from the rice in the first process of milling possess a low degree of feeding value, and being also deficient in flavor and digestibility they are of little value as food for stock; they are more valuable as a fertilizer. They not only restore to the land part of the elements of fertility removed by the crop, but increase the porosity of the soil. They also make an excellent mulch for garden and orchard.

Hull ashes.—In passing through rice-milling districts large quantities of hull ashes will be noticed. These have been very little used by farmers and gardeners, under the general impression that they are of no value. One hundred pounds of hull ashes contain 0.82 pound of phosphoric acid and 0.93 pound of potash. There are many other better sources of potash and phosphoric acid. The amount contained in the hull ashes would not pay the cost of scattering them over the fields.

The planter who burns his straw and sells his rice in the paddy loses 63.92 per cent of the total mineral matter of the crop. If the

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[a] Yearbook, U. S. Dept. of Agriculture, for 1896, p. 607.

[b] Bulletin 24, Louisiana Agricultural Experiment Station.

rice straw and the hulls be returned to the soil as manure, 86.36 per cent of the mineral matter of the crop will be restored, and the loss would be only 13.64 per cent. The present method of burning rice hulls can not be too severely condemned, but doubtless will be continued as long as rice is sold in the paddy. Hulling is a process requiring very simple and inexpensive machinery. It can be done profitably upon the farm, and is done in most of the great rice-producing countries. In addition to their fertilizing value, the removal of the hull on the farm saves the expense for sacks and freight charge for the extra bulk and weight, the hulls forming generally about 20 per cent of the weight of the paddy. It also enables the farmer as well as the miller to determine with greater exactness the quality of the grain, thereby removing that element of uncertainty which always operates to the detriment of the farmer. It should be mentioned, however, that the hard husk of the rice tends to prevent attacks of weevil on the grain, and that rice with all or a portion of the husks on keeps better in storage or long shipment.

Rice polish.—This is the fine flour resulting from the polishing process. It is a valuable stock food, being rich in albuminoids as well as carbohydrates.

RICE CULTIVATION IN SOUTHWESTERN LOUISIANA AND SOUTHEASTERN TEXAS.

It is necessary to treat of rice production in southwestern Louisiana and southeastern Texas separately, because the methods are in some respects different from those practiced in any other part of the world.

METHODS OF CULTURE REVOLUTIONIZED.

In 1884 and 1885 a few farmers from the northwestern Prairie States settled on the great southern prairie which extends along the coast from the parish of St. Mary in Louisiana to the Texas line—about 140 miles. Finding that rice, which had been grown for many years for home consumption, but by oriental methods, was well suited to the conditions of agriculture here, they commenced immediately to adapt the agricultural machinery to which they had been accustomed to the rice industry. The gang plow, disk harrow, drill, and broadcast seeder were readily adjusted, but the twine binder encountered a number of serious obstacles. However, by the close of 1886 the principal difficulties had been overcome. Wherever prairies were found sufficiently level, with an intersecting creek which could be used to flood them, they were surrounded by a small levee thrown up by a road grader or by a plow with a strong wing attached to the moldboard extending it 4 or 5 feet. These levees were usually 12 to

24 inches high, and the interior ditch was 12 to 18 inches deep and 4 or 5 feet wide. Very few interior ditches were made for drainage. The land was so level that fields of 40 and 80 acres were common. Large crops were produced. The prairies were practically free from injurious grasses, and the creek or river water was soft and bore no damaging seeds to the fields. The rice fields were handled like the bonanza wheat farms of Dakota, and fortunes were made. Levees were cheaply constructed; little attention was paid to drainage, more than to remove the surface water; shocking, stacking, and thrashing were done in a very careless manner; the main object being, apparently, to plant a large acreage and harvest a certain number of bushels, regardless of quality. Ultimate failure was certain, but it was hastened by drought. A succession of dry years followed. The creeks failed, and reservoirs were found to be expensive and unreliable.

The soil and climatic conditions in southeastern Texas are almost precisely like those in southwestern Louisiana. Rice culture in this section requires no separate treatment. What is applicable to the one applies also to the other. There is a belt of prairie well suited to rice extending from the Sabine River west for 250 miles or more along the coast. Within a few years large farms have been opened and devoted to this cereal with excellent returns.

IRRIGATION.

Pumping water from streams.—To provide a reliable supply of water, pumping plants for raising water from the streams were gradually put in. The elevation of the prairies above the streams varies from 6 to 38 feet, the larger proportion being from 15 to 25 feet. At first, farms along the streams and lakes were irrigated; gradually large surface canals were constructed.

Canals for irrigation.—Irrigating canals were started in a small way in Acadia Parish, La., in 1890. In 1894 a canal 40 feet wide was built for 15 miles with 10 miles of laterals. This was followed by the Crowley Canal and the Riverside Canal. In nearly every township there are one or more ridges slightly above the surrounding land. On these, surface canals are built from 20 to 150 feet in width, according to the area to be watered. The sides of the canal are raised from 4 to 5 feet with plows and scrapers or with grading machinery. Grading machines work very well, as the soil is a loam or a clay loam free from stones. Side gates are inserted in the embankment as frequently as necessary. Laterals are run from the main canal to accommodate remote farms. Powerful pumping plants are erected on the bank of the river at the head of the surface canal. These canals, where well constructed and operated, prove entirely successful, and make the rice crop a practical certainty over a large section of country. They range in irrigating capacity from 1,000 to 30,000 acres. The usual water rent charged the planter by the canal company is 324 pounds of rough rice per acre watered.

Deep wells for irrigation.—Scarcely had the surface canals been accepted as a success when southwestern Louisiana was startled by the announcement that there were strata of gravel under the surface of the entire section, varying from 125 to 200 feet in some districts to 400 to 600 feet in others, containing a large supply of water which would, of its own pressure, either flow or come so near the surface that it could be readily pumped.

Pipes of 2, 3, 4, 6, and 8 inch size have been sunk to the gravel and pumped continuously for months without serious diminution of the supply. The water is soft, at a constant temperature of about 70° F., and absolutely free from injurious seeds or minerals. Such is the facility with which these wells are made that a 6-inch tube has been put down to the full depth required—200 feet—in fourteen hours. Thus far it has been found that a 6-inch pipe will furnish sufficient water to flood 60 to 80 acres. Such wells are used for the irrigation of other crops than rice.

A 6-inch well will furnish a constant stream for a 4 to 5 inch pump. A system of such wells may be put down 30 to 40 feet apart. Such a combination of wells may be united just below water level, and all be run by one engine and pump. Water rises naturally in these wells to within 20 feet of the surface, and a number of flowing wells have been secured. The lift is not greater than from rivers, lakes, or bayous into canals. Eight 4-inch wells united at the top can be run by one 16-inch pump and a 50-horsepower engine, and will flood 500 or more acres of rice.

The total cost of an irrigating plant sufficient for flooding 200 acres is from $2,000 to $3,000. It requires about seventy days' pumping for the rice season.

HARVESTING AND THRASHING.

The operations of harvesting and thrashing the rice crop in southwestern Louisiana are performed with the self-binder and the steam thrasher. The use of the former is favored by the size of the fields and by the character of the soil. The use of the latter, while it frequently involves the breakage of considerable grain, is a cheap, rapid, and effective method of separating the rice from the straw. Without the use of such machines the large cultural operations of this section would be impossible.

PROSPECTS FOR THE EXTENSION OF THE RICE INDUSTRY.

The outlook for the further extension of rice culture is very promising. According to the best estimates there are about 10,000,000 acres of land in the five States bordering the Gulf of Mexico well suited to rice cultivation. The amount which can be successfully irrigated by present methods, using the available surface and artesian flows, does not exceed 3,000,000 acres. The balance of the land could probably be brought into cultivation were it necessary, but the cost would, perhaps, be prohibitive at present prices. Three million acres is a conservative estimate of the area which can be easily irrigated. The best results require rotation of crops; consequently only one-half of that area, or 1,500,000 acres, would be in rice at any one time. At an average yield of 10 barrels (of 162 pounds) per acre, 1,500,000 acres of rice would produce nearly 2,500,000,000 pounds of cleaned rice, nearly six times the amount of our present consumption. There is no satisfactory reason why the United States should not grow and mill all of its own rice and become an exporter.

The employment of machinery in the rice fields of the Southwest similar to that used in the great wheat fields of California and the Dakotas is revolutionizing the methods of cultivation and greatly reducing the cost. The American rice grower, employing higher priced labor than any other rice grower of the world, in all probability will ultimately be able to market his crop at the least cost and the greatest profit. If, in addition, the same relative improvement can be secured in the rice itself, and if varieties which yield from 80 to 90 per cent of head rice in the finished product can be successfully introduced, American rice growers will be able to command the highest prices for their product in the markets of the world.